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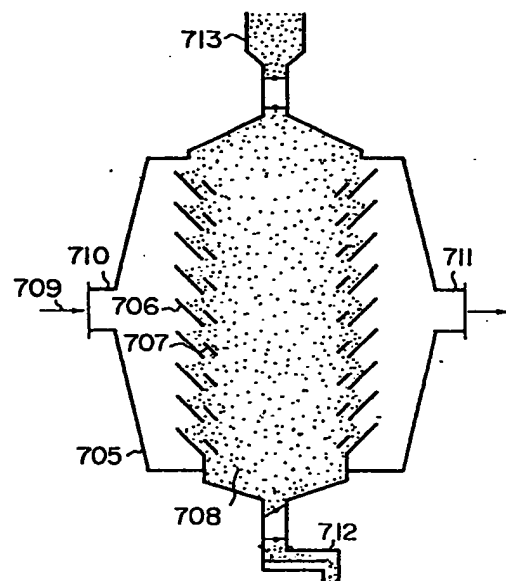
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54 Louver construction for supporting a charge of particulate material.

57 A louver construction arranged in a closed vessel formed with an inlet port and an outlet port for particulate material aligned in a vertical direction and an inlet port and an outlet port for gas having its components adsorbed on the particulate material aligned in a horizontal direction. In addition to a plurality of sets of main louver elements oriented in the direction of flow of the particulate material and spaced apart from one another a predetermined distance with the main louver elements of each set angling toward each other a predetermined amount with respect to the direction of flow of the gas, at least one other set of louver elements is arranged in such a manner that the louver elements angling a predetermined amount toward each other with respect to the direction of flow of the gas are each interposed between the main louver elements of the adjacent sets.



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LOUVER CONSTRUCTION FOR SUPPORTING A CHARGE
OF PARTICULATE MATERIAL

1 FIELD OF THE INVENTION

This invention relates to louver constructions for supporting a charge of particulate material, and more particularly it is concerned with a louver construction having particular utility in providing charged layers of an adsorbing agent for adsorbing sulfur dioxide gas contained in the waste gas of a boiler, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view in explanation of a construction of the prior art for supporting charged layers of particulate material using louvers as support members;

Fig. 2 is a view in explanation of the flow of particles in the charged layers taking place when a louver construction of the prior art is used;

15 Figs. 3 - 6 are views in explanation of the principles of the present invention, Fig. 3 showing the manner in which charge pressure acts on the sublouver, Fig. 4 showing a state of stresses of a charged layer in planes, Fig. 5 showing a state of stresses on the sublouver and Fig. 6 being a diagrammatic representation of the relation between sublouver angle and P_T/P_F ;

20 Fig. 7 is a schematic view of the louver construction comprising one embodiment of the invention;

Fig. 8 is a schematic view of one form of

1 louver arrangement of the louver construction shown
in Fig. 7; and

Fig. 9 is a schematic view of another form of
louver arrangement of the louver construction shown in
5 Fig. 7.

DESCRIPTION OF THE PRIOR ART

Heretofore, it has been usual practice to use
a louver construction shown in Fig. 1 in which a multi-
plicity of louvers 1 in a tilting position are arranged
10 vertically for providing charged layers of the movable
type for supporting particulate material 2 thereon,
when gas is introduced into the charged layers of the
particulate material which may be a particulate adsorbing
agent or catalyst to bring the particulate material
15 into contact with certain components of the gas to
cause them to react with each other or to collect such
components. For this purpose, a louver construction
as shown in Fig. 1 has usually been used in which a
plurality of louvers 1 in a tilting position are arranged
20 vertically for supporting particulate material 2 in
movable charged layers.

The movable charged layers of the particulate
material 2 supported on the louvers 1 of this construction
have nonmovable masses 3 of the particulate material 2
25 formed on the louvers 1 as shown in Fig. 2. This phenomenon
causes the disadvantage that when the gas treated by the
particulate material 2 contains large volumes of dust as

1 is the case with waste gas of a coal-burning boiler,
for example, the dust is gradually accumulated in the
nonmovable masses 3, resulting in a windage loss. Also,
when the louver construction is used for causing adsorp-
5 tion of sulfur dioxide gas in the gas on activated
carbon or other carbon base adsorbing agent, the
adsorbing agent in the nonmovable masses 3 has sulfur
dioxide gas adsorbed thereon in an amount exceeding the
saturation point over a prolonged period of time, and
10 the adsorbing agent in the nonmovable masses 3 has
its surface wet with sulfuric acid produced from the
adsorbed sulfur dioxide gas, causing corrosion to the
louvers 1.

SUMMARY OF THE INVENTION

15 OBJECT OF THE INVENTION

An object of this invention is to provide a
louver construction suitable for supporting particulate
material in charged layers which is capable of avoiding
corrosion by permitting the particulate material to move
20 smoothly while being supported on the louvers.

Another object is to provide a louver construc-
tion suitable for supporting particulate material in
charged layers which is capable of keeping nonmovable
masses of the particulate material from being formed on
25 the louvers, to thereby prevent a windage loss.

1 STATEMENT OF THE INVENTION

 This invention is based on the discovery made
as a result of an experiment conducted by us by using
colored particulate material that in the louver con-
5 struction of the prior art shown in Fig. 1, the load
applied in a horizontal direction by a particulate
material group 4 constituting a main stream and the load
applied by the nonmovable masses of the particulate
material balance, so that the particles of the nonmovable
10 masses 3 are kept from flowing into the particulate
material group 4 constituting the main stream. This
discovery has led to the concept of allowing the particles
of the nonmovable masses 3 to flow into the main stream
by causing the aforesaid loads to become unbalanced.

15 The outstanding characteristic of the inven-
tion is that sublouvers are arranged in the vicinity of
the louvers of the louver construction of the prior art.

 The invention enables the nonmovable masses
of particulate material hitherto formed on the louvers
20 to be eliminated in a louver construction of the movable
charged layer type. Thus in the louver construction
according to the invention, dust in the waste gas is
prevented from being accumulated in the nonmovable
masses of particulate material. When sulfur dioxide gas
25 in the gas is adsorbed on an adsorbing agent, the ad-
sorbing agent can be moved downwardly before the sulfur
dioxide gas is adsorbed thereon in an amount exceeding
the saturation point, thereby preventing corrosion of

1 the louvers.

Additional and other objects, features and advantages of the invention will become apparent from the description set forth hereinafter when considered
5 in conjunction with the accompanying drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Prior to description of the preferred embodiment, the principles of the invention will be described in some detail.

10 Fig. 3 shows the principles of the invention in which 300 designates main louvers shown in broken lines, 400 designates sublouvers each located in the vicinity of one of the main louvers 3, and 500 designates particulate material supported thereon in movable charged
15 layers.

Lacking a free surface, the particular material 500 on the sublouvers 400 has a downwardly oriented pressure P_v act thereon and it moves downwardly by overcoming a horizontally directed pressure P_h when
20 it moves. When this is the case, whether or not smooth movement is obtained depends on the relation between a downwardly directed force exerted by a pressure P and the frictional force of the particulate material acting on the surfaces of the sublouvers 400.

25 When a vertical pressure P acting on the sublouvers 400 and a horizontal pressure kP are considered to produce a maximum main stress σ_1 and a minimum main

1 stress σ_2 respectively, as shown in Fig. 4, the direction of the stress acting on the sublouvers 400 can be given by the following equation:

$$\tan \alpha = \tau / \sigma \quad \dots\dots (1)$$

The following equations are obtained:

$$\sigma = \frac{\sigma_1 - \sigma_2}{2} \cos(90^\circ + \phi_i) + \frac{\sigma_1 + \sigma_2}{2} \dots\dots (2)$$

$$\tau = \frac{\sigma_1 - \sigma_2}{2} \sin(90^\circ + \phi_i) \quad \dots\dots (3)$$

$$k = (1 - \sin \phi_i) / (1 + \sin \phi_i) \quad \dots\dots (4)$$

5 In the equations set forth hereinabove, ϕ_i is the angle of friction between the particles of the particulate material. Since $\sigma_1 = P$ and $\sigma_2 = kP$, if one assumes that $\phi_i = 33$, $\tan \alpha = 0.445$ from equations (1) - (4), so that $\alpha = 24^\circ$. If the angle formed between the $\tan \alpha$ and the horizontal is denoted by β ,
10 then $\beta = 52.5^\circ$.

If the angle of inclination of the sublouvers 400 with respect to the horizontal is denoted by θ as shown in Fig. 5, then a downwardly directed force ρ_τ
15 acting along the louver surface on the basis of ρ and a frictional force ρ_F acting on the louver surface are given by the following equations:

$$\rho_{\tau} = \rho \cdot \sin (\theta - 37.5^{\circ}) \quad \dots\dots (5)$$

$$\rho_F = M \cdot \rho \cdot \cos (\theta - 37.5^{\circ}) \quad \dots\dots (6)$$

1 From equations (5) and (6), the relation between θ and ρ/ρ_F can be obtained as shown in Fig. 6. For the particulate material on the sublouvers to flow downwardly, it is necessary that the relation $\rho_{\tau}/\rho_F > 1$ hold. It
5 will be understood that in Fig. 6 the angle θ formed by the sublouver and the horizontal has only to be set at $\theta > 70^{\circ}$ under the aforesaid conditions. It is more preferable that $\theta = 74^{\circ}$.

A preferred embodiment of the invention will
10 now be described by referring to Fig. 7 which shows a louver construction suitable for use in supporting the movable charged layers of an adsorbing agent for carrying out desulfurization of waste gas. An adsorption tower
705 has arranged therein a plurality of sets of louvers
15 in a tilting position located vertically, each set including main louvers 706 and sublouvers 707 forming two vertical rows spaced apart from each other a suitable distance. An adsorbing agent 708 is charged between the two vertical rows of the main louver 706 and the
20 sublouvers 707. Waste gas 709 as of a boiler, not shown, is introduced through a gas inlet port 710 into the adsorption tower 705 and flows through the clearance between the louvers of one row and the charged layers

1 of the adsorbing agent before being discharged from the
tower 705 through the clearance between the louvers
of the other row and a gas outlet port 711. As the
adsorbing agent flows through the adsorption tower 705
5 as described hereinabove, the sulfur dioxide gas
contained in the waste gas is adsorbed and removed from
the waste gas. With time, the adsorbing agent reaches
the saturation point, so that a predetermined quantity
of adsorbing agent is continuously withdrawn from the
10 adsorption tower 705 through a remover 712 located at
the bottom of the tower 705 for transfer to a regenerat-
ing device, not shown, from which it is returned to a
hopper 713 at the top of the tower 705 through which
it is supplied to the interior of the tower 705 in
15 circulation.

The details of the louver construction will
be described by referring to Fig. 8 in which the sublouver
707 is located relative to the main louver 706 in such
a manner that it is interposed between the adjacent two
20 main louvers 706 and 706' and an upstream end 707q
thereof is located on a straight line connecting lower
ends 706p and 706'p' of the main louvers 706 and 706'
respectively or inside such straight line. Also, when
the main louvers 706 and 706' form with the horizontal
25 an angle α , the sublouver 707 is preferably arranged in
a manner to satisfy the following relation:

$$\alpha \leq \beta \quad \dots (7)$$

1 in which α is the angle formed by the sublouver 707
and the horizontal. Stated differently, the sublouvers
707 are preferably located in such a manner that the
direction of its inclination is the same as the direction
5 of inclination of the main louvers 707 and the angle β
is equal to or larger than the angle α .

The angle α is preferably set at a value higher
than the angle of repose of the particulate material.
Based on our experiences, the angle β is set at a value
10 smaller than 90° . Thus equation (7) can be rewritten
as follows:

$$30^\circ < \alpha \leq \beta < 90^\circ \quad \dots\dots (7')$$

The dimensional relation between the main louvers 706
and the sublouvers 707 is as follows. The main louvers
706 and the sublouvers 707 have lengths which are such
15 that the particulate material (adsorbing agent) applies
no charge pressure to the main louver 706 positioned
against the sublouver 707.

By arranging the sublouvers 707 relative to
the main louvers 706, the sublouvers 707 is capable of
20 bearing a portion of the load applied by the particulate
material in a portion Y, so that no load is applied to
a portion X above the main louvers 706 and smooth flow
of the particulate material on the main louvers 706
can be obtained. In the embodiment shown and described
25 hereinabove, the sublouvers 707 are smaller in dimension

1 than the main louvers 706 (less than one-half) and sub-
stantially no nonmovable masses of particulate material
are formed on the sublouvers 707. Thus the movement of
the particulate material in the absorption tower
5 follows paths I, II and III.

The adsorbing agent used in the embodiment
shown and described hereinabove had an angle of repose
of 30° with respect to the horizontal, so that the angles
of inclination α and β of the main louvers 706 and
10 the sublouvers 707 were selected at 45° with respect
to the horizontal. As aforesaid, the angles of
inclination α and β of the main louvers 706 and the
sublouvers 707 need not coincide with each other and any
value may be selected for them so long as it is larger
15 than the angle of repose of the particulate material.
The main louvers and the sublouvers were dimensioned such
that a portion A of the main louvers 706, a portion
B of the sublouvers 707, a gap C between the main louvers
706, a vertical distance between the lower end of the
20 main louver 706 and the upper end of the sublouver 707
and a horizontal distance E between the end of the
main louver 716 and the end of the sublouver 707 were
100 mm, 50 mm, 80 mm, 40 mm and between 0 and 10 mm,
respectively. When a charge of carbon base adsorbing
25 agent with a particle size of 5 - 10 mm in diameter was
filled between the louvers of this construction and
successively withdrawn through the bottom of the tower,
smooth movement of the adsorbing agent was obtained with

1 no nonmovable masses on the main louvers and substantial-
ly no nonmovable masses on the sublouvers.

Fig. 9 shows another embodiment of the inven-
tion which is distinct from the embodiment shown in
5 Fig. 8 in that second sublouvers 714 smaller than the
sublouvers 707 in dimension are arranged inwardly of
the latter. In this embodiment, the second sublouvers
714 are related to the sublouvers 707 in the same manner
as the sublouvers 707 are related as described herein-
10 above to the main louvers 706. The louvers had the
dimensions such that a portion A of the main louvers
706, a portion B of the sublouvers 707 and a portion C
of the second sublouvers 714 were 100 mm, 40 mm and 15 mm
respectively. The sublouvers 707 and the second sub-
15 louvers 714 were arranged such that their lower ends
were each located on a perpendicular to the lower ends
of the main louvers 706. It is to be understood that
the lower ends of the sublouvers and the second sub-
louvers may be located inwardly of the perpendicular
20 to the lower ends of the main louvers, as described
hereinabove. A charge of a mixture of flyash in the
waste gas of a coal-burning boiler with the adsorbing
agent of the particle size described by referring to the
embodiment shown and described by referring to Fig. 8
25 was filled between the louvers of the aforesaid construc-
tion and allowed to move. Despite the fact that the
fractional force acting between the particles has increased
as a result of incorporation of the flyash in the

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1 adsorbing agent, no nonmvable masses were formed on the
louvers.

WHAT IS CLAIMED IS:

1. A louver construction arranged in a vessel charged with particulate material for supporting charged layers of the particulate material, comprising a
5 plurality of sets of main louver elements oriented in the direction of flow of the particulate material and spaced apart from one another a predetermined distance with the main louver elements of each set being juxtaposed against and angling toward each other a predetermined
10 amount with respect to the direction of flow of the particulate material, wherein the improvements comprises:
at least one other set of louver elements arranged between the main louver elements of the adjacent sets, said louver elements of said at least one other
15 set being juxtaposed against and angling toward each other a predetermined amount with respect to the direction of flow of the particulate material.
2. A louver construction as claimed in claim 1, wherein the louver elements of said at least one other
20 set are located in such a manner that each said louver element has its upper end located on a straight line connecting lower ends of the main louver elements of the adjacent sets or said straight line exits in a region in which it does not cross the main louver elements
25 of the adjacent sets.
3. A louver construction as claimed in claim 1 or 2, wherein the degree at which said louver elements of said at least one other set angle with respect to the

direction of flow of the particulate material is equal to or smaller than the angle at which said main louver elements of the adjacent sets angle with respect to the direction of flow of the particulate material.

5 4. A louver construction as claimed in any one of claims 1 - 3, wherein said louver elements of said at least one other set each have a length large enough not to allow the charged layers of the particulate material to apply pressure to said main louver elements
10 of each set.

5. A louver construction arranged in a closed vessel formed with an inlet port and an outlet port for particulate material aligned in a vertical direction and an inlet port and an outlet port for gas having its
15 components adsorbed on the particulate material aligned in a horizontal direction, comprising a plurality of sets of main louver elements oriented in the direction of flow of the particulate material and spaced apart from one another a predetermined distance with the main
20 louver elements of each set being juxtaposed against and angling toward each other a predetermined amount with respect to the direction of flow of the gas, wherein the improvement comprises:

at least one other set of louver elements
25 arranged between the main louver elements of the adjacent sets, said louver elements of said another set being juxtaposed against and angling toward each other a predetermined amount with respect to the direction of flow

of said gas.

6. A louver construction as claimed in claim 5, wherein said louver elements of said at least one other set are arranged in such a manner that an end of each
- 5 said louver element located on the upstream side of the direction of flow of the particulate material is located on two parallel lines obtained by connecting ends of the main louver elements of the adjacent sets located on the downstream side of the direction of
- 10 flow of the particulate material or in a region defined between said two parallel straight lines.
7. A louver construction as claimed in claim 5 or 6, wherein the degree at which said louver elements of said set angle with respect to the direction of flow
- 15 of the gas is equal to or larger than the degree at which the main louver elements of the adjacent sets angle with respect to the direction of flow of the gas.
8. A louver construction as claimed in any one of claims 5 - 7, wherein said louver elements of said
- 20 set each have a length large enough not to allow charged layers of the particulate material to apply pressure to the main louver elements of the adjacent sets.

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FIG. 1
PRIOR ART

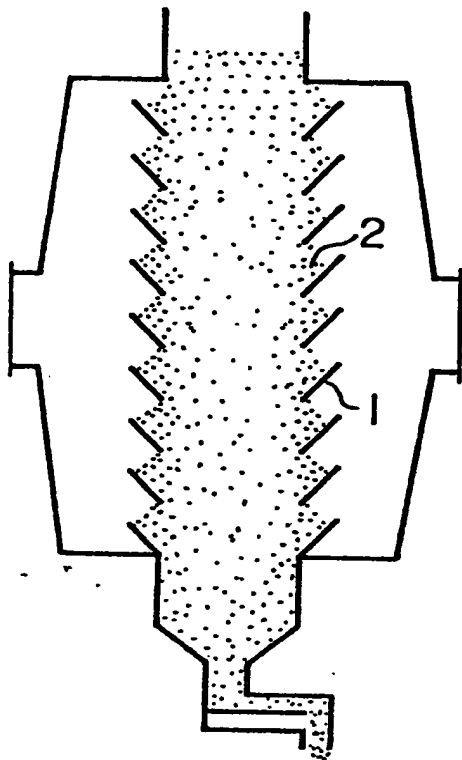


FIG. 2
PRIOR ART

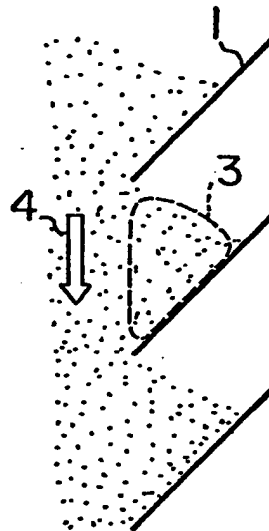


FIG. 3

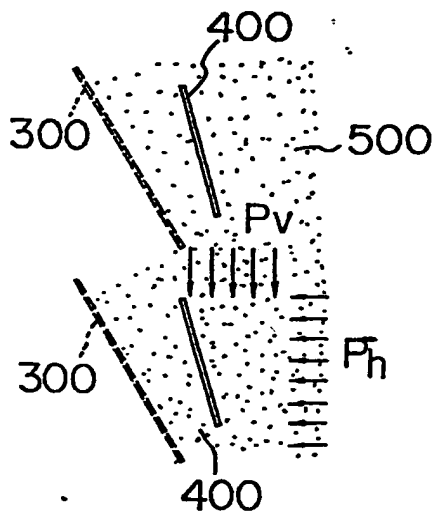


FIG. 4

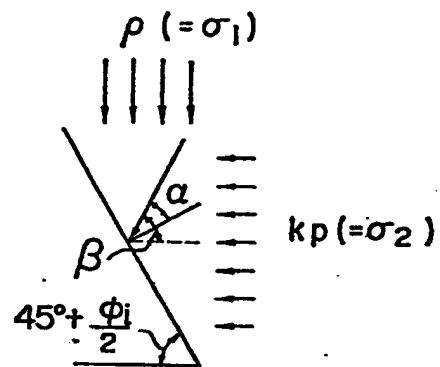


FIG. 5

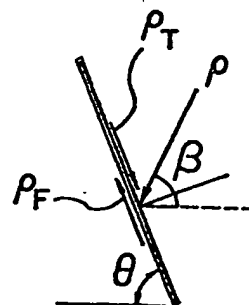


FIG. 6

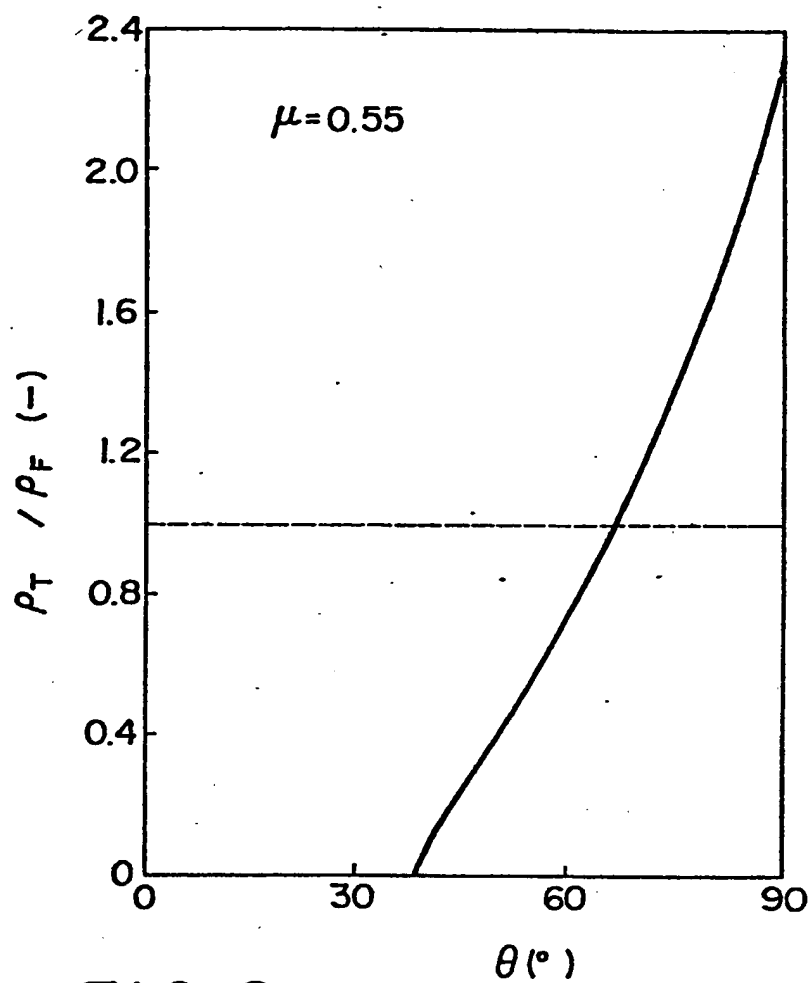


FIG. 8

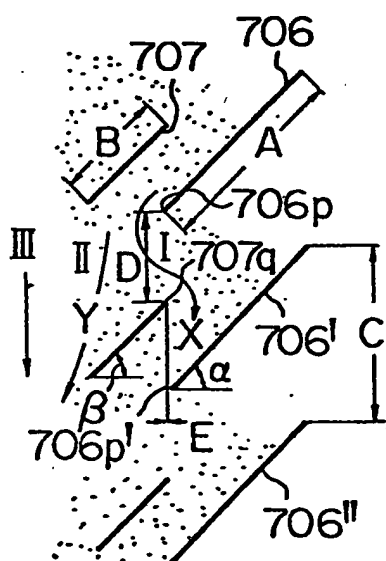


FIG. 9

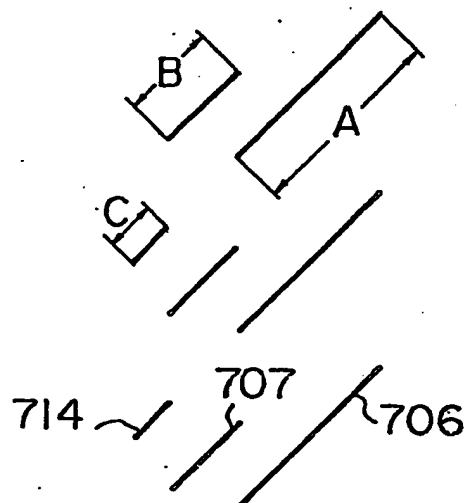


FIG. 7

